Monitoring northern fulmars in the Canadian arctic: plot locations and counts at selected colonies

M. L. Mallory and A. J. Gaston

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Monitoring northern fulmars in the Canadian arctic: plot locations and counts at selected colonies

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Abstract

The Northern Fulmar (*Fulmarus glacialis*) is a common seabird found across marine areas of eastern Nunavut. It breeds at colonies located on cliffs >250 m high, most of which drop directly into the ocean, and which are often in remote, inaccessible locations. As well, many fulmars are dark and difficult to spot against the rock of the region, meaning that censusing fulmar colonies is difficult. For these reasons, our knowledge of fulmar populations in Arctic Canada is coarse. Here we present photographic and geo-referenced data of colony censuses and plot counts for fulmars at six large colonies in Nunavut, as a baseline for long-term monitoring of these important sites.

Résumé

Le fulmar boréal (*Fulmarus glacialis*) est un oiseau de mer commun dans l'ensemble de l'aire marine de l'est du Nunavut. Ses colonies de nidification se retrouvent sur des falaises de plus de 250 m de hauteur dont la plupart tombent directement dans l'océan et qui sont souvent dans des endroits isolés et inaccessible. De plus, beaucoup de fulmars sont de couleur foncé et difficile à apercevoir contre le roc de la région, ce qui rend le recensement des colonies de fulmars difficile. Pour ces raisons, nos connaissances des populations de fulmars dans l'arctique canadien sont grossières. Nous présentons ici des données photographiques et géolocalisés de recensements de colonies et de parcelles pour six grandes colonies de fulmars du Nuavut comme base de référence pour la surveillance à long terme de ces sites d'importance.

Acknowledgements

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1.0 General Introduction

The Northern Fulmar (*Fulmarus glacialis*) is an abundant seabird nesting in eastern Arctic Canada (Hatch and Nettleship 1998). It is difficult to census for several reasons. First, colonies are located at very remote and inhospitable locations (Fig. 1), typically on sheer ledges that are often shrouded in fog. Second, fulmars exhibit substantial colour variation (Fisher 1952, van Franeker 1986), typically classified into 4 types: LL (white), L (light), D (dark) and DD (very dark). Many fulmars in this region are D or DD and hence shades of gray -- also the predominant colour of sedimentary cliffs in the region. These two factors mean that trying to count fulmars from above the colonies or from aerial photos may require considerable time to get proper viewing conditions. Third, many birds can be missed by counting from the base of the cliff, because they are hidden from view on small indented ledges, or behind vegetation. Finally, most of the cliffs where fulmars nest are fractured sedimentary rock, making climbing approaches unsafe for large parts of the colony. Taken altogether, these factors mean that estimates of fulmar colony sizes come with considerable sources of error. Nettleship and Smith (1975) considered colony estimates within orders of magnitude.

All Northern Fulmar colonies in Nunavut are situated on seaward-facing cliffs, mostly >250 m high. Only the colony at Cape Vera can be adequately viewed from the base of the cliffs. At all other colonies, counts must be made either from a boat, from sea ice, or from vantage points along the cliff top. The latter method is feasible only where the cliffs are indented, so that it is possible to view from headlands. Counting from the cliff top also requires accessing the top of the colony – not always easily accomplished. Counting from boats is difficult in all but the calmest conditions. The most convenient method is to count from the stable platform of sea ice, but counting is not likely to be useful before 10 June, owing to the pre-laying exodus of most breeders in late May (Hatch and Nettleship 1998). Consequently, in many years, sea ice has broken up before counting is possible. A combination of all these factors accounts for the currently very fragmented state of knowledge on Northern Fulmar colonies in arctic Canada.

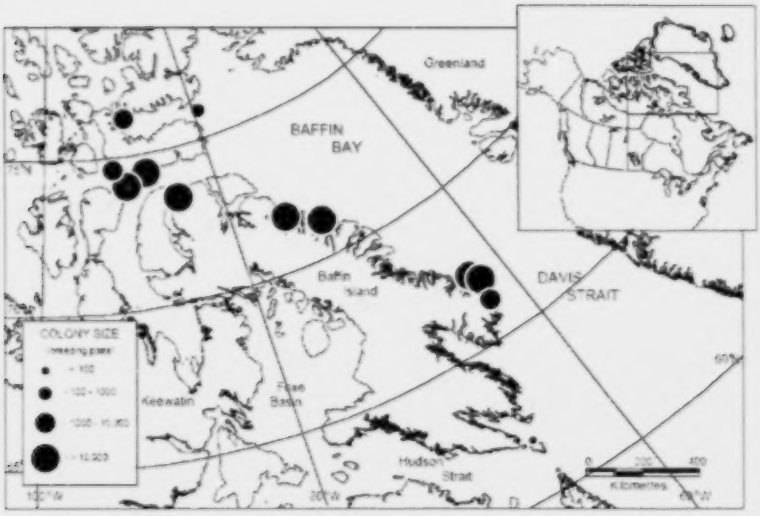

Figure 1. Locations of Northern Fulmar colonies in Nunavut, Canada.

Coarse estimates of the population size of colonies in the Canadian Arctic were made in the 1970s and 1980s (Brown et al. 1975, Hatch and Nettleship 1998, but see Gaston and Smith 1987, Robards et al. 2000), sometimes with estimates as orders of magnitude (Nettleship and Smith 1975). These were largely based on single surveys of sites, many of which were taken from fixed-wing aircraft. These estimates have been published in various forms, with some revision of numbers after the earliest estimates, but most refer to data from the original surveys (Nettleship 1974a,b, 1980, Nettleship and Smith 1975, Brown et al. 1975, Gaston and Smith 1987, Hatch and Nettleship 1998).

Between 2000-2004, we updated census information for the majority of northern fulmar colonies in Nunavut, and in some cases we established plots for future monitoring efforts. In this paper we provide a photographic record of the locations of counts and plots, so that these sites can be resurveyed to examine trends in population size at colonies.

Previous estimates of population size sometimes have been expressed as "pairs" (e.g. Nettleship and Smith 1975) or as "individuals" (Hatch and Nettleship 1998). In some cases, "individuals" refers to the number of birds counted on the colony during a census (e.g. Gaston and Smith 1987), while in other cases, "individuals" refers to the total number of breeders and is therefore double the estimated number of "pairs". It is not clear whether estimates given by earlier authors expressed in "pairs", (or "individuals" = 2 times "pairs") were comparable to our estimates of numbers of occupied sites, because the derivation of previous estimates is unknown except for Prince Leopold Island (where pairs meant an estimate of total breeding pairs, derived by correcting counts of individuals using a correction factor based on intensively studied breeding plots).

For most colonies considered here, we counted occupied sites (number of solitary individuals + number of pairs), the numbers of which tend to vary less from day–to-day than total numbers of individuals (Gaston et al. in review). Based on our observations at Cape Vera and Prince Leopold Island, numbers of "occupied sites" will usually exceed the actual number of breeding pairs by 1.2-1.5 times during the period when most counts were made (period of minimum day-to-day variation, approximately 18 June – 20 July in Nunavut).

For each colony, we provide a brief description and location of the site, the site-specific methods used for the work, and the relevant co-ordinates of census locations and plot locations for future comparative counts.

2.0 Sites

2.1 Cape Searle

The northern fulmar colony at Cape Searle (67°14'N, 62°28'W) has been of interest to the Canadian Wildlife Service (CWS) for some time, and is a candidate National Wildlife Area (Mallory et al. 2003). The extensive arctic coastal surveys in the 1970s identified this as a major colony in the eastern arctic, supporting up to 100,000 breeding pairs (Wynne-Edwards 1952, Nettleship and Smith 1975).

To census the Cape Searle colony, two surveys were conducted (11-14 June 2001, 6-8 June 2002). Both were undertaken by snow machine, which typically required 6-7 hours to reach the site from Qikiqtarjuaq.

2.1.1 Colony Census

We conducted the colony censuses from locations around the colony on the sea-ice (Table 1). We established a count of overall colony size by estimating the number of birds along the cliffs and on top of the towers. A Kowa spotting scope with a 20-60X ocular was used to count birds, and to count the proportion of light and dark phase fulmars. For determination of colour ratios, we counted either a fixed number of birds (e.g. 100) and recorded how many were the bright white variant (LL; Hatch and Nettleship 1998), or recorded proportions of white birds on discrete, defined ledges or patches. The top of the first (outer) tower is only visible from north of Cape Searle, and the top of the second (inner) tower is not visible from the ice. Hence, we used the estimate of the number of birds on the first tower, and then acquired an aerial photograph of Cape Searle to extrapolate the number of birds nesting on top of the second tower.

It is important to note that much of the Cape Searle rock is gray, and that most birds nest along the upper parts of the cliff and on top of the towers. This creates considerable

difficulties in picking out some darker birds, particularly at a distance, and thus our estimates are considered approximate.

Fulmar counts for 2001 and 2002 are presented in Table 1, with corresponding photographs in Appendix 1. In 2001, the count for the top of the first tower is an underestimate, as fog impaired visibility considerably. Thus, we counted approximately 10 300 fulmars on the cliffs, and we estimated seeing at least another 3,000 circling in flight, representing > 13 000 fulmars, but recognizing that this was an underestimate. In 2002, we counted most of the same broad areas on the cliff faces as were counted in 2001 (Table 2). Approximately 5,000 fulmars were counted along the faces of the rock towers, but because there were many areas we could not see, we estimate that another 5,000 birds could have been out of view. In 2002 we were unable to census the western sections of the colony on the north side of Qaqulluit Island due to cloud. This area would be challenging to view even under suitable conditions, and in 2001 we estimated that 2,000 fulmars nested across this rock face. Together these totaled 12 000 fulmars nesting along the cliffs.

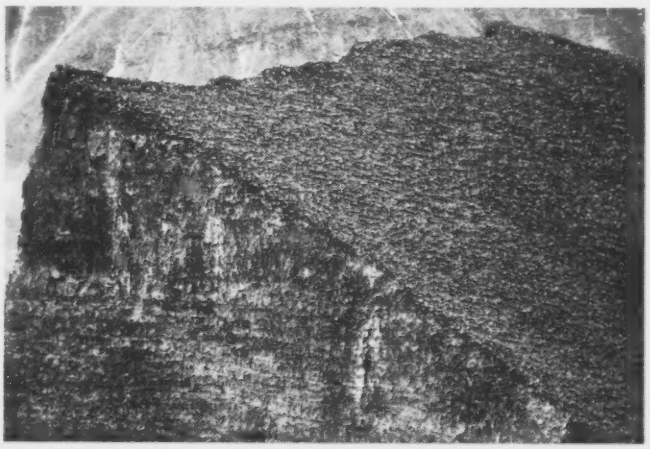

Figure 2. A portion (~20%) of the outer rock tower surface at Cape Searle (photo by P. Mineau).

We were able to get a good view of the surface of the first tower in 2002, albeit from a distance. We estimated that this surface alone supported 14 000 fulmars (estimated as

140 groups of 100 birds, visible against a recent snowfall). Similarly, a count of a separate photograph (taken by P. Mineau) of ~ 20% of the surface of the tower (Fig. 2) yielded 3229 birds, or 16 145 for the entire surface (assuming uniform density across the tower). Thus, 14 000 birds seems to be a good estimate of the number of sites on the first tower. An aerial photograph (Fig. 3) indicated that the surface of the second tower is 30% larger than that of the first tower. Assuming the breeding density of birds is similar on both towers, about 18 000 pairs breed on the surface of the second tower (14 000 x 1.3).

Based on the 2001 and 2002 counts, we estimate that approximately 44 000 fulmars were at this site. However, given the cryptic nature of the species' coloration and that some spots could not be viewed well, it is quite probable that the count could have been 20% higher, or 53 000 birds.

2.1.2 Density on Cliffs

The distribution of nesting fulmars on the cliffs of Cape Searle was not uniform, although there was consistency in regards to elevation around the cliff (Table 2). The bottom third of the cliff faces typically had very few nesting fulmars per field of view (mean 1.07 ± 0.31 SE), with greater densities in the middle third (2.47 ± 0.55) and highest densities along the upper third (8.04 ± 1.32). Fulmars nested in similar densities on each of the towers and rock faces (Kruskal-Wallis test, KW=2.12, P=0.71), but fulmars nested in higher densities as one moved higher on the towers (KW=33.4, P<0.001).

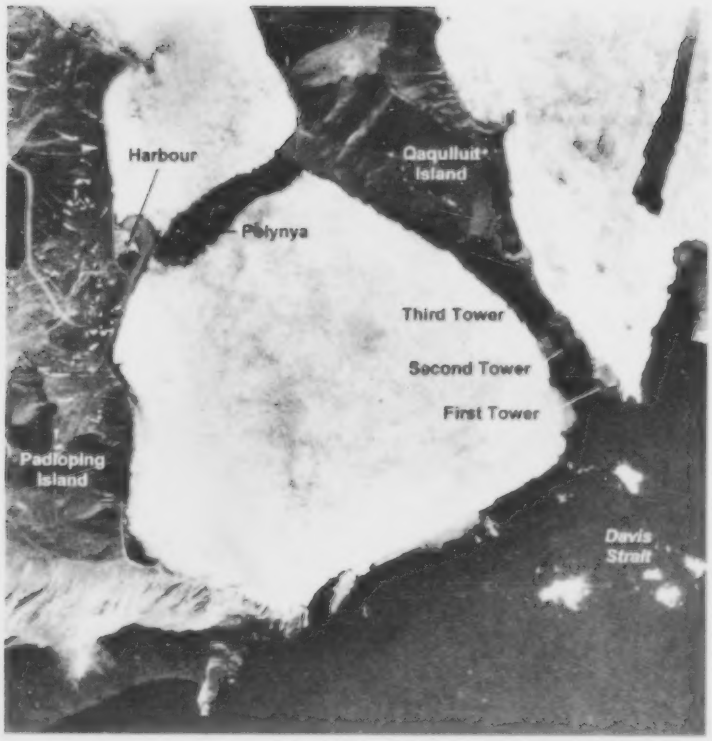

Figure 3. Locations of the towers at Cape Searle, showing the larger second tower.

Table 1. Colony census of Northern Fulmars at Cape Searle during June 2001 and 2002. Locations correspond to photographs in Appendix A.

Survey Location				2001		2002			
Latitude	Longitude	Location	Photograph	Light Birds	Dark Birds	Light Birds	Dark Birds	Habitat Description	Comments
67.23228	62.45292	A	S1	5	120	9	84	Ledge line	Eastern tip, looking due W
67.23228	62.45292	B	S1, S2	3	66	6	37	Ledge line	Eastern tip, ledge below red rock
67.23228	62.45292	C	S2		100		50	Grassy pocket	Eastern tip, above red rock line
67.23228	62.45292	D	S2		1,000		500	Grassy pocket	Eastern tip, above Section C
67.22717	62.45828	A	S3	14	108	22	98	Grassy pocket	Southern side, facing due N
67.22717	62.45828	B	S3		70	3	33	Small grass and scree	Southern side
67.22717	62.45828	C	S3	0	20			Small grass	Southern side
67.22717	62.45828	A1	S4		150	23	116	Grassy pocket	Southern side, west of A, B, C
67.22717	62.45828	B1	S4		50	9	47	Small grass and scree	Southern side, west of A, B, C
67.22305	62.47118	A	S5	0	20	2	13	Grassy slope	Southern side
		B	S5, S6	20	157	27	128	Ledge line	Southern side, ledge at top of light brown rock
		C1	S6	0	25	3	14	Eroded patch	Southern side
		C2	S6	0	14	0	9	Grassy pocket	Southern side
67.22217	62.46861	D1	S7	15	85	20	50	Grassy pocket	Southern side
		D2	S7	0	10	4	6	Grassy slope	Southern side
		D3	S7	20	150	17	150	Grassy pocket	Southern side
		D4	S7	18	60	7	61	Small grass and scree	Southern side, above D3 grass patches
		E	S7		300		*	Small grass and scree	Southern side, just before ICGU colony
67.22973	62.50333	A	S8		4500		14,000	Flat, grassy top	Northern side, looking S from N
		B	S8		1,000		2,000	Grassy area	Northern side, below A between two main towers
		C	S8		50		100	Small grassy area	Northern side, below B on second tower
		D	S8		200		300	Eroded crack	Northern side, above C on second tower
		E	S8				1,000	Grassy area	Northern side, above D near top
		F	S8				50	Lichen and grass area	Northern side
		G	S8		1,000			Grass, scree and ledge	Northern side, third tower, central on tower
		H			1,000	12	119	Small grass and scree	Northern side, third tower, NW on tower
									South side of 3rd bluff near top, scattered 500 birds
									South side of 4th bluff, max 700 birds
									Very few nests on 5th bluff near GLGU colony

* estimate approximately 1,000 birds in the cliff face west of D4, including E from 2001

Table 2. Counts of birds in field of view at varying locations around Cape Searle. At each location the rock face was divided into thirds and birds in the middle of each third were counted. These values are not corrected for the difference in area encompassed by the field of view at increasing angles of elevation. However, these differences were considered relatively small for most counts, given the distance to the observation point.

Position	Tower	Elevation	One Minute Count					Mean (SE)
			1	2	3	4	5	
67.232 N 62.453 W	E Outer	Bottom	8	8	0	0	0	3.2 (2.0)
		Middle	0	0	0	0	2	0.4 (0.4)
		Upper	20	7	4	8	6	9.0 (2.8)
67.227 N 62.458 W	S Outer	Bottom	4	0	0	0	0	0.8 (0.8)
		Middle	2	0	0	0	0	0.4 (0.4)
		Upper	0	0	0	0	0	0.0
	SE Inner	Bottom	0	1	0	0	2	0.6 (0.4)
		Middle	0	0	0	0	2	0.4 (0.4)
		Upper	6	10	17	8	4	9.0 (2.2)
67.223 N 62.471 W	S Inner	Bottom	0	1	1	0	0	0.4 (0.2)
		Middle	0	1	0	0	0	0.2 (0.2)
		Upper	4	5	5	3	0	3.4 (0.9)
67.222 N 62.468 W	S Third	Bottom	3	0	5	0	0	1.6 (1.0)
		Middle	5	3	0	7	1	3.2 (1.3)
		Upper	5	12	12	21	3	10.6 (3.2)
67.215 N 62.495 W	S Third	Bottom	0	0	0	0	0	0.0
		Middle	0	5	2	0	2	1.8 (0.9)
		Upper	26	4	8	0	5	8.6 (4.5)
	S Third	Bottom	0	0	0	2	0	0.4 (0.4)
		Middle	2	16	5	9	7	7.8 (2.4)
		Upper	4	0	4	1	5	2.8 (1.0)
67.230 N 62.503 W	N Outer	Bottom	6	0	3	0	0	1.8 (1.2)
		Middle	0	0	0	0	10	2.0 (2.0)
		Upper	5	0	4	3	6	3.6 (1.0)
	N Inner	Bottom	2	0	0	1	1	0.8 (0.4)
		Middle	12	4	3	4	7	6.0 (1.6)
		Upper	20	20	30	18	39	25.4 (4.0)

2.2 Cape Vera

The fulmar colony at Cape Vera (76°15'N, 89°15'W) has been known since the start of the 20th century (Sverdrup 1904). It is located beside the Hell Gate – Cardigan Strait Polynya on northern Devon Island. The colony has been reported to support between 7500 pairs (Alexander et al. 1991) to 25 000 pairs (Hatch and Nettleship 1998). We conducted a census of the colony in 2004 by working out of the Cape Vera research station base camp.

2.2.1 Colony Census

On 10 July 2004, between 1600-2000 hrs, two biologists walked the extent of the Cape Vera colony along the base of the cliffs and counted birds on cliff sections from 18 stations located < 200 m from the cliff base (Table 3, Fig. 4). We also worked from the top of the colony to establish long-term monitoring plots.

Figure 4. Southern portion of the Cape Vera colony, showing extensive scree slope and beach below cliffs.

Table 3. Census positions and counts at Cape Vera, 10 July 2004.

Latitude	Longitude	Count
76° 15' 51.5"	89° 15' 19.4"	480
76° 15' 40.4"	89° 15' 10.4"	130
76° 15' 25.8"	89° 14' 1.6"	170
76° 15' 10.5"	89° 13' 48.1"	830
76° 14' 59.4"	89° 13' 17.3"	980
76° 14' 48.3"	89° 12' 29.2"	990
76° 14' 39.4"	89° 12' 6.2"	250
76° 14' 33.4"	89° 11' 58.9"	310
76° 14' 29.5"	89° 11' 59"	640
76° 14' 15.4"	89° 12' 14.8"	260
76° 14' 4.1"	89° 12' 38.6"	600
76° 13' 53"	89° 13' 13.4"	910
76° 13' 47.7"	89° 13' 58"	600
76° 13' 45.6"	89° 14' 40.4"	1460
76° 13' 41.7"	89° 15' 10.6"	1390
76° 13' 41.7"	89° 15' 10.6"	150*
* *lower part of slope*		Total: 10,150

We counted 10 150 fulmars from the base of the cliff, plus another 783 fulmars on study plots visible only from above. We estimated that approximately 3000 fulmars in total (including the plots) could have been obscured from counting locations below the cliffs. Together, we estimate 13 000 birds on the colony that day. More than half of these birds were observed in the southern third of the colony (including Fig. 4), where cliffs are more incised, and photographs indicate nesting densities of > 2 nests/m^2 on some ledges.

2.2.2 Plots

We established 11 plots for long-term monitoring of population counts at Cape Vera (Appendix B, Table 4). Within these plots, we also identified approximately 300 locations of specific occupied sites, with the goal of monitoring variation in reproductive success from specific sites (or pairs, assuming high nest and pair fidelity; Hatch and Nettleship 1998).

Table 4. Observation locations for plots at Cape Vera (see also Appendix B).

Latitude	Longitude	Count
76° 14' 40"	89° 13' 19"	T1
76° 14' 45.2"	89° 13' 23.9"	T2, U1, U2
76° 14' 21.7"	89° 13' 28.1"	V, W
76° 14' 4.7"	89° 13' 35.7"	X
76° 14' 3"	89° 13' 59.8"	Y
76° 13' 56.6"	89° 14' 53.4"	Z1, Z2, Z3

2.3 Prince Leopold Island

This colony, at 74°02'N, 90°W, has been visited by biologists more often than any other Arctic fulmar colony, beginning with T.W. Barry in 1958 (Barry 1961), who estimated the population of Northern Fulmars at about 150 000 birds. Barry thought that fulmars also might nest on Cape Clarence, the adjacent headland of Somerset Island, but subsequent observers have failed to confirm this. The fulmars were subject to intensive studies at Prince Leopold Island during 1975-78 by field crews led by Philip Taylor (1975) and Anne Linton (now Anne Greene, 1976-78) under the direction of D. N. Nettleship (Nettleship 1977, Nettleship et al. 1986, Hatch and Nettleship 1998). An estimate of the total population, based on work carried out in 1977, was given as 62 000 breeding pairs by Hatch and Nettleship (1998). Monitoring plots, outlined on photographs, were set up in 1975 and counted throughout the 1975-78 seasons and again during visits in 1980, 1984 and 1988 (Gaston et al. in review).

Further intensive breeding biology studies on the Prince Leopold Island fulmars were carried out during 2001-2003 (Gaston et al. in press). During those seasons, daily counts were made of some of the monitoring plots established in 1975, using the same protocol as previously. Counts were made from the same spot (marked by a cairn, in most cases) and at the same time each day (17.00-18.00 hr)

2.3.1 Colony Census

Because of the length of the occupied cliffs, the census of Northern Fulmars at Prince Leopold Island was carried out over several days, spread over two seasons, as opportunity permitted. The occupied cliffs were broken down into seven zones (Fig. 5) which differed in aspect and structure. The unit of counting was the "occupied site", so two birds together at a single site were scored as one site. Consequently, numbers were not directly comparable to counts made at some other colonies, where all birds were summed (see above). Simultaneous counts made at breeding study plots (Gaston et al. in

press) were used to estimate how the numbers counted related to numbers of breeding pairs.

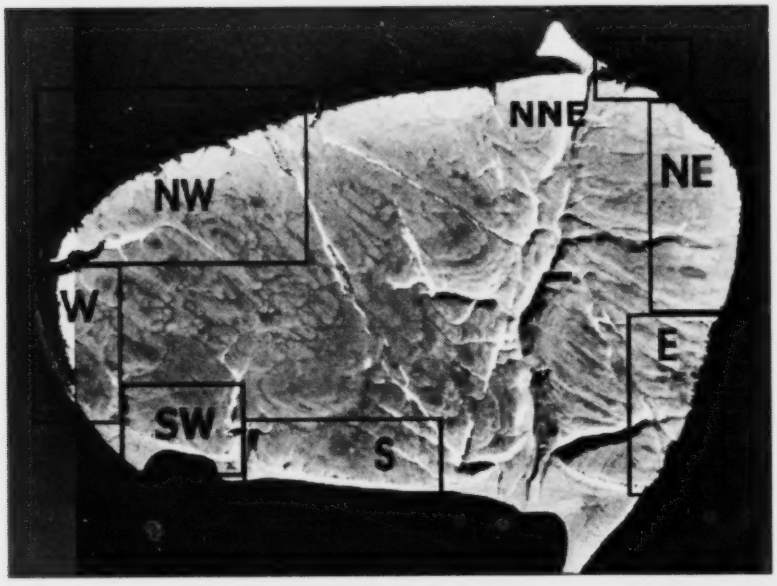

Figure 5. Aerial photograph of Prince Leopold Island, showing zones for census work.

All counts were made from the cliff top. From this vantage point, varying amounts of the lower cliffs are visible and observers estimated for each view the proportion of the occupied cliff probably out of sight. In addition, some parts of the cliffs could not be viewed at all from above. The straight-line distance between the start and end of invisible sections was measured by means of GPS fixes and the number of fulmars using the hidden area was estimated on the basis of numbers counted per linear unit of cliff for observable parts of the same zone. Details of numbers counted from each observation point are given in Tables 5-8 and counts are summarised by zone in Table 9.

Table 2. Counts of the east cliffs at Prince Leopold Island, 30 June 2001.

Area	GPS location		Time	Est. % visible	Count	Adjusted for % visible	Notes
	N	W					
I (S)			805	100	145	145	From D
H (S)			825	100	175	175	
G (N)				50	87	174	From E
H (N)			850	90	240	267	From I
F (N)				80	86	108	
E (N)				80	184	230	
D (N)				80	122	153	
I (S)				100	161	161	From H
K (S)			1000	80	134	168	
J (N)				80	75	94	Est. 50 on areas to N of J
L (S, stack)				80	94	118	
L (S, remainder)				80	143	179	
K (N)				100	71	71	
M (S)				80	2	3	
L (N, stack)				80	40	50	
L (N, remainder)				80	39	49	
O (S, outer part)				80	20	25	
N (S)				80	75	94	
M (N)				80	65	81	
O (S)				80	88	110	
N (N)				80	12	15	
P (S)				80	156	195	
O (N)			1110	80	109	136	
Q (S)				80	147	184	
S (S, outer part)				80	117	146	from P
S (S, inner)				80	46	58	from R
P (N)			1210	80	434	543	
R (N)				80	50	63	
Q (N)				80	91	114	
T (S)			1230	80	210	263	
S (N)				80	340	425	
U (S)				80	31	39	
T (N)				80	47	59	
V (S)				80	49	61	
U (N)				80	20	25	
W (S)			1330	80	30	38	
V (N)				80	43	54	
X (S)	74 01.383	89 54.838		80	88	110	
W (N)				80	79	99	from X
Y (S)				80	70	88	
Z (S, outer part)	74 01.523	89 54.656		100	469	469	from W
X (N)				80	31	39	
Z (S, inner part)			1400	80	225	281	from Y

Y (N)			1420	70	280	400	
C (N)	74 00.305	89 56.790	1750	80	190	238	from D
D (S)				80	187	234	from C
C (S)				20	30	150	from B
A (N)				80	37	46	
A (S)				80	77	96	
AA	74 00.203	89 57.093		50	83	166	
East cliff total					5824	7281	

NB: From K - Y, approx 70-90% of occupied area was visible; we used 80% average

Table 6. Counts of the northeast cliffs at Prince Leopold Island, 30 June 2001.

Area	GPS location		Time	Count	Adjusted for % visible	Notes
	N	W				
ZZ(S)			1430	16		
Z(N)				28		
ZZ+1	74 01.971	89 53.842		33		Looking N from ZZ+1, approx 125 m of cliff visible
ZZ+2	74 02.096	89 53.743		22		Looking N, approx. 40 m cliff
Estimate for whole area					400	

Table 7. Counts of the south cliffs at Prince Leopold Island, 9 July 2001. Distances to the base of the occupied area and lengths of cliff counted were estimated with a laser range-finder.

Count point	GPS location		Time	Direction from count point	Distance to base of occupied area (m)	Length of cliff counted (m)	Number of sites counted	Notes
	N	W						
SC1	74 00.429	90 03.600	1021	>W			7	
SC2	74 00.408	90 03.834		>W			50	
SC3	74 00.403	90 03.937	1035	>E	102	65	188	
				>W	102	20	15	Small stack
SC4	74 00.415	90 03.982		>W	81	35	71	
SC5	74 00.413	90 04.082	1100	>E	80	40	140	
				>W	75	35	49	farther
				>W	75	30	44	nearer
SC6	74 00.413	90 04.231	1115	>E	70	90	133	
				>W	105		35	near stack, top part
SC7	74 00.435	90 04.447	1125	>W	125	65	69	near stack only
SC8	74 00.437	90 04.543	1135	>E	110	45	39	
				>W	125	45	91	stack 80 m away
SC9	74 00.447	90 04.707	1142	>E	115	35	83	
				>W	120	40	96	
SC10	74 00.454	90 04.797	1148	>E	117	40	129	
				>W	80	30	52	
SC11	74 00.478	90 04.979	1150	>W	125	60	72	
SC12	74 00.476	90 04.962	1203	>E	100	60	46	
SC13	74 00.519	90 05.175		>E	100	40	82	
SC14	74 00.541	90 05.162	1215	>W	105	100	101	
SC15	74 00.530	90 05.471	1300	>E	120	60	77	
SC16	74 00.483	90 05.343	1308	>W	100	40	72	
SC17	74 00.500	90 05.510	1317	>E	80	30	56	
				>W	60	30	17	nearer stack
SC18	74 00.515	90 05.586	1320	>E	60	30	31	
				>W	70	35	8	
SC19	74 00.509	90 05.715	1330	>W	50	30	22	
SC20	74 00.514	90 05.749	1330	>W	50	30	21	
SC21	74 00.528	90 05.874	1335	>E	50	30	16	
				>W	70	30	34	
SC22	74 00.517	90 05.976	1343	>E	60	30	54	
				>W	70	35	42	
SC23	74 00.522	90 06.002	1345	>W	70	50	55	same headland as SC22

SC24	74 00.544	90 06.473	1357	>E	120	40	72	
								same headland as SC24, ridge
SC25	74 00.547	90 06.510	1403	>W	130	40	121	130 m >W
SC26	74 00.567	90 06.589	1409	>E	140	50	1	
								headland counted is
SC27	74 00.563	90 06.895	1415	>W	140	50	59	155 m >W
SC28	74 00.561	90 07.117	1426	>E	80	50	61	
								same headland as SC28, 50 m
SC29	74 00.567	90 07.180	1430	>W	80	50	128	>W
SC30	74 00.596	90 07.263	1438	>W	65	30	64	
				>E	80	40	140	
SC31	74 00.595	90 07.342	1455	>E	75	30	133	
SC32	74 00.541	90 07.626	end of occupied area					
								headland counted is
SC33	74 00.660	90 07.817	1508	>E	70	30	44	218 m >E
								headland counted is
SC34	74 00.682	90 07.989	1530	>W	100	40	32	274 m >W
SC35	74 00.703	90 08.459	start of occupation again					
			1542	>E/below	70	30	18	
SC36	74 00.705	90 08.665	1545	>E	93	25	59	
				>W	93	25	31	
								only a few birds to west of
SC37	74 00.727	90 08.775	1554	>E	80	30	39	SC37
				end of occupied area			3099	
SC38	74 00.801	90 08.940		above S Spit		1895		
SW cliffs								
From SC38				>W			317	Far side of gorge
Not recorded			1700		80	300	223	Additional to above sites
Totals, SW cliffs						300	540	

Table 8. Counts of the west and north cliffs at Prince Leopold Island, 28 July 2000.

Count point	Time	GPS N	W	Length of cliff counted (m) (m)	Number of sites counted (birds)	Notes
West cliffs						
W1	1615	74 01.656	90 24.722	100	195	
W2	1635	74 01.744	90 24.699	50	108	Green's cairn II
W3	1650			50	55	
W4	1702			60	35	
W5	1707			50	116	
W6	1712	74 02.360	90 24.725	40	123	
W7	1720			40	94	
W8	1724			80	180	N side of main W gully
Total				940	906	
North cliffs						
NW9	1753	74 02.360	90 24.725	40	32	
NW10	1800			50	85	
NW11	1807	74 03.015	90 23.299	60	54	
NW12	1829			30	12	
NW13	1842	74 03.298	90 21.510	80	222	
NW14	1909	74 03.452	90 09.025	40	26	
Total				600	431	

2.3.2 Plots

The number of study plots on which Northern Fulmars have been counted at Prince Leopold Island has varied somewhat from year to year. All are situated in the East cliff zone. Those for which the maximum amount of data are available are situated at AA, A, C, D, G, H and J (Fig. 6) and these plots are demarcated in Appendix C. Breeding sites numbered in 1976 and subsequently are also shown.

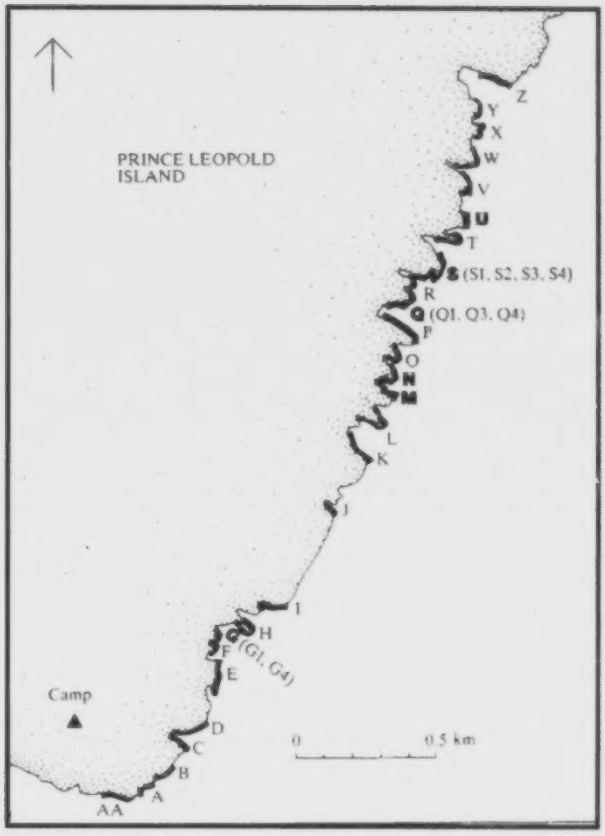

Figure 6. Locations of study plots on eastern Prince Leopold Island.

Table 9. Counts and correction factors for census of Northern Fulmars at Prince Leopold island, 2000-2001.

Year	Date	Section	Length occupied (m) (LO)	Length counted (m) (LC)	Correction factor (CF)	Ratio of pairs/sites (RA)	Count (N)	Sites / m (N/(LC*CF))	Occupied sites (OS)	OS corrected to peak attendance	Breeding pairs (OS*RA)
2000	28-Jul	W	1500	940	0.8	0.98	906	1.20	1807	2857	1771
	28-Jul	N	3000	600	0.8	0.98	431	0.90	2694	4258	2640
	31-Jul	S	2510	2300	0.8	0.98	3356	1.82	4578	7236	4486
2001	30-Jun	SE	2440	2000	0.5-0.8	0.74	5824	3.57	8706	10391	6442
	09-Jul	S	2400	1890	0.8	0.62	3099	2.05	4919	4062	3050
	09-Jul	SW	700	300	0.8	0.62	540	2.25	1575	1575	977
Not counted		NE	2800			0.74			400	477	296
Not counted		NNE	1200			0.74		c. 1.2	1500	1790	1110
Total (S coast est for 2001)			14150	8030			14156	2.35	21601	25410	16286

2.4 Baillarge Bay

The Baillarge Bay colony (73°25'N, 84°30'W) was mapped by Fisher (1952) on the basis of information obtained by Peter Freuchen in 1924. The colony was surveyed from a fixed-wing aircraft by D.N. Nettleship in 1973 and visited on the ground in 1977 by AG (brief helicopter survey) and in 1981 by Don Reid and Pierre Mineau (27-31 August to band nestlings – 50 banded). In 2001, AG and Roger Bull visited the colony by helicopter, landing briefly on the cliff top near the southwest end of the colony and making a count of colour morph ratios. None of these visits was able to provide a satisfactory estimate of population size. The colony was listed by Hatch and Nettleship (1998) as 25 000 breeding pairs.

2.4.1. Colony census

The cliffs at the Baillarge Bay colony rise to more than 400 m and the total distance from one end of the occupied area to the other is nearly 14 km. However, the cliffs are broken by gullies that extend down to sea level at six places, reducing the occupied length to approximately 8.5 km. Fulmars nest at all altitudes from about 30 m above sea level. The colony was visited by helicopter on 11 June 2002 by AG and Kyle Elliot from 1315 – 1800 hr. Counts were made through 40X telescopes from land-fast sea ice at six points spread along the length of the colony (Table 10, Fig. 7).

Light conditions were felt to be less than ideal, as the observers had to contend with glare coming off the ice surface around them. The distance to the colony, at about 1.5 km was close to the extreme for identifying birds through a 40 power telescope. Consequently, we assumed that many dark-morph birds were missed during the count, as well as birds partially obscured by vegetation of irregularities in the cliff. We counted 8605 occupied sites (Table 10) excluding what we termed "the lower section", which consisted of eight similar buttresses. We counted 270 sites on the northernmost buttress (Fig. 8) and extrapolated this count to the whole section to give an estimate of 2160. We added 1000 sites for areas that were out of sight from our count points, to give a total estimate of 11

765 occupied sites. It seems likely that at approximately 50% of birds in the area counted went unrecorded, so we estimate the number of sites occupied that day at 20 000 – 25 000.

Figure 7. A counting location along the fulmar colony at Baillarge Bay, June 2002.

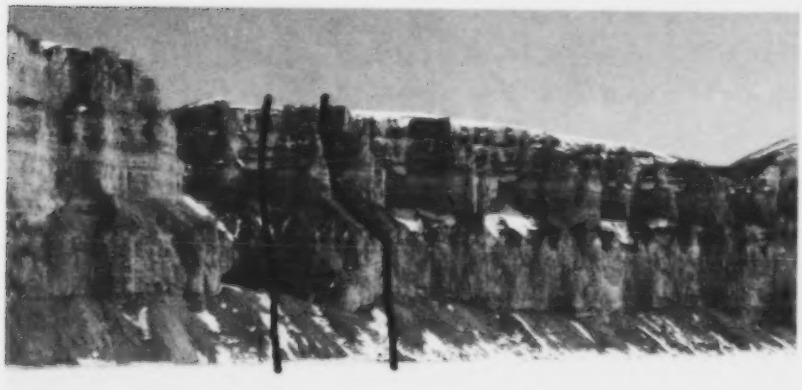

Figure 8. Northernmost buttress, where 270 fulmar sites were counted.

Table 10. Counts of the Ballarge Bay colony, 11 June 2002

Count point	GPS location		Time	Count	Notes
	N	W			
Ship Point			1320		No birds seen
Counts arranged moving from NE - SW					
Upper cliff edge, N end of colony	73 28.23	84 12.35			
BB2	73 28.55	84 14.65	1400	521	NE end to first sea-level gully
				313	Gully 1 - gully 2
BB3	73 27.81	84 18.61	1430	365	Gully 2 - gully 3
				0	Gully 3 - gully 4
BB4	73 26.29	84 25.78	1510	2244	Gully 4 - gully 5
BB5	73 26.27	84 29.94	1550	1648	Gully 5 - gully 6
BB6	73 25.55	84 33.98	1630	1853	Gully 6 - start of "lower section"
				270*	NE-most bastion of "lower section", from BB6
BB1	73 25.55	84 33.98	1340	1651	SW end - "lower section"
Upper cliff edge, S end of colony	73 24.36	84 37.12			

*Extrapolated to eight bastions, gives estimate of 2160
NB: minimum of 1000 birds estimated obscured from count points

2.5 Hobhouse Inlet

The Northern Fulmar colony at Hobhouse Inlet is situated on south-facing cliffs between Hobhouse Inlet and Stratton Inlet on the south coast of Devon Island (74°28'N, 86°50'W). It was first discovered to science by S.D. MacDonald in July 1972 and subsequently surveyed from the air by D.N. Nettleship on 2 August 1972 (Nettleship 1974b). Nettleship estimated the size initially as 10 000 – 100 000 pairs (Nettleship 1974b). Later it was estimated at 75 000 breeding pairs (Brown et al. 1975), but this was modified to 25 000 pairs in subsequent publications (Nettleship 1980, Hatch and Nettleship 1998). It was visited briefly by AG in July 1976 by helicopter, but the cliff top has few indentations and it was clear that no census, or useful monitoring, could be conducted from above.

2.5.1. Colony census

The colony was visited by AG and Ulrich Steiner on 2 July 2001. The total length of the occupied area was measured, by means of GPS fixes at both ends, as 10.5 km and occupation by fulmars was found to be more or less continuous along the entire stretch. The height of the cliff, measured by GPS at six points along the cliff edge, varied between 352-480 m elevation. Counts were made from the sea ice at the foot of the colony through 40X telescopes at ranges from 1300 to 1600 m from the cliff foot. Light conditions were excellent and although the distance was large the observers considered that they missed few birds: we assumed that we counted 90% of occupied sites. Counts were made from six locations (Table 11) giving a total of 8482 occupied sites counted on an estimated 4.73 km of cliff. Extrapolation from this sample yielded a total colony estimate of 21 525 occupied sites [(8482*(10.5/4.73))/0.9]. Count areas are shown in Appendix D.

Table 11. Count location, distance from base of cliff, height of cliff, estimated length of cliff counted and numbers of sites occupied at the Hobhouse Inlet colony during the census on 2 July 2001. Each section counted was divided in half and counted separately by two observers. The lengths of cliff counted were estimated by trigonometry, using cliff height and distance to cliff.

Count Point	GPS-location		Cliff height (m)	Distance to cliff (m)	Length of cliff counted (m)	Number of sites counted	S..es m
	N	W					
HI6	74° 27.246	86° 57.456	352	1300	512	745	1.45
HI7	74° 27.365	86° 55.790	400	1300	488	1134	2.32
HI8	74° 27.403	86° 52.250	450	1400	783	668	0.86
HI9	74° 27.322	86° 49.119	460	1400	1027	2346	2.28
HI10	74° 27.366	86° 54.904	460	1600	1194	1468	1.23
HI11	74° 27.387	86° 42.737	360	1300	721	2121	2.94

2.6 Cape Liddon

Considering its position, close to areas visited regularly by expeditions during the 19th century, it is surprising that the colony at Cape Liddon was not identified until 1970 when C.J. Jonkel reported seeing it during polar bear surveys. Earlier reports of a colony at Cape Riley (notes in Fisher 1952), not far to the west of Cape Liddon, may refer to the present colony: no fulmars were reported from Cape Riley in the 20th century and the two headlands look somewhat alike. An aerial survey of the colony in 1972 suggested a population between 1000 – 10 000 breeding pairs (Nettleship 1974b) and it was subsequently reported as 10 000 pairs (Brown et al. 1975, Nettleship and Smith 1975, Nettleship 1980).

The colony is situated on a headland on the west side of Radstock Bay (74°37'N, 91°10'W), a deep indentation on the south coast of Devon Island. The cliffs face south or southeast and vary from 100-220 m elevation. Previous estimates of the colony placed it in the region of 10 000 breeding pairs (Brown et al. 1975, Hatch and Nettleship 1998).

2.6.1 Colony census

Counts were made from the sea-ice by AG and Shoshanah Jacobs between 1915 – 2200 hr on 11 June 2002. Fulmars were counted from the consolidated pack ice extending out from the foot of the cliff, with 40X, 80 mm telescopes, at distances estimated from GPS fixes as 0.5-1.0 km (Fig. 9).

The total length of the occupied cliffs was estimated from GPS fixes at 2.4 km. Three sections were counted, aggregating 1.7 km of cliff. We counted 5091 occupied sites (Table 12). Virtually all sites would have been visible from the observation points. Light conditions were considered less than ideal, as the sun was behind the cliffs, especially at the east end, where birds were most dense. We estimated that 20% of occupied sites

were either obscured by irregularities in the cliff, or missed because of shadow, giving an estimate of 8970 occupied sites [(5091*(2.4/1.7))/0.8].

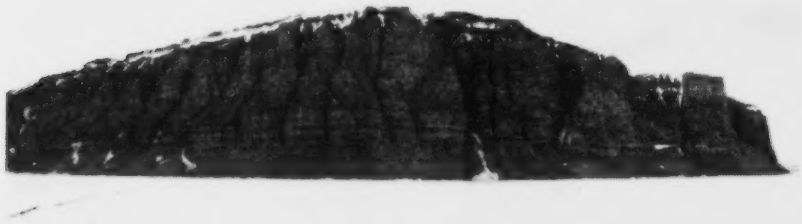

Figure 9. The fulmar colony at Cape Liddon, June 2002.

Table 12. Counts of the Cape Liddon colony, 11 June 2002.

Count point	GPS location		Time	Est. length of cliff counted (m)	Count	Notes
	N	W				
Upper cliff edge, E end of colony	74 38.39	91 07.34				
CL1	74 38.35	91 05.42	1915	500	1870	Light difficult
CL2	74 37.46	91 85.93	2010	500	1295	
CL3	74 37.15	91 09.62	2200	700	1926	
Upper cliff edge, W end of colony	74 37.62	91 11.31				

3.0 Discussion

The six colonies examined in this report are key terrestrial and marine habitat sites in Nunavut (Alexander et al. 1991, Mallory and Fontaine 2004), and two of them are protected areas (Prince Leopold Island Migratory Bird Sanctuary, and Baillarge Bay as part of Sirmilik National Park). Fulmars and other seabirds in Arctic Canada face threats to their breeding, feeding and wintering habitats from climate change, resource extraction and associated shipping and oil spills, ecotourism, and long-range transport of contaminants (e.g. FEARO 1984, Hall and Johnston 1995, Vinnikov et al. 1999, Braune et al. 2001, 2002, Grumet et al. 2001, Thompson and Ollason 2001, Jenouvrier et al. 2003) and thus knowledge of their population sizes and trends is essential for sound management of anthropogenic stressors that might affect these birds

A recent review of the Canadian Arctic fulmar population suggests that there are probably fewer fulmars than we have thought since the initial surveys of the 1970s (as evidenced by the counts presented in this report), but that the differences are largely methodological (Gaston et al. in review). The data presented here represent the most recent and detailed information on fulmar counts in Arctic Canada. Importantly, we have provided co-ordinates and, in most cases, photographs of counted locations against which future comparisons can be made with some confidence. Although the methods used at each colony differ, due in part to the observer or the physical and time constraints presented at the particular site, the overall approach is analogous to that developed for Thick-billed Murres (*Uria lomvia*) (Birkhead and Nettleship 1980). This approach stresses that at large colonies, such as those for fulmars, reliable tracking of population trends is best accomplished by monitoring established plots. With plots established only at Prince Leopold Island and Cape Vera, these two colonies are best suited to monitoring population trends of Northern Fulmars in Arctic Canada.

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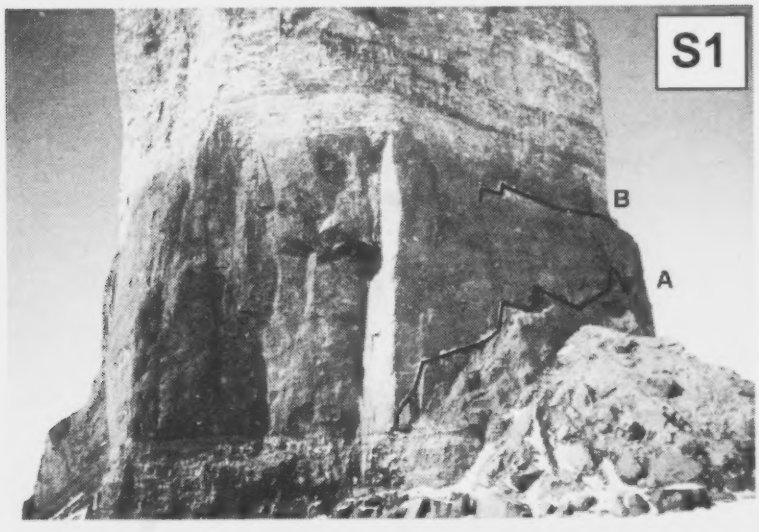
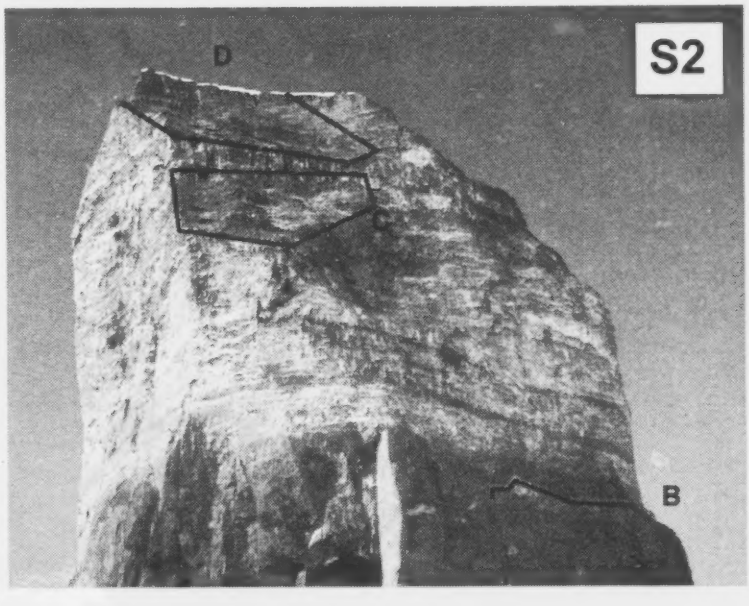
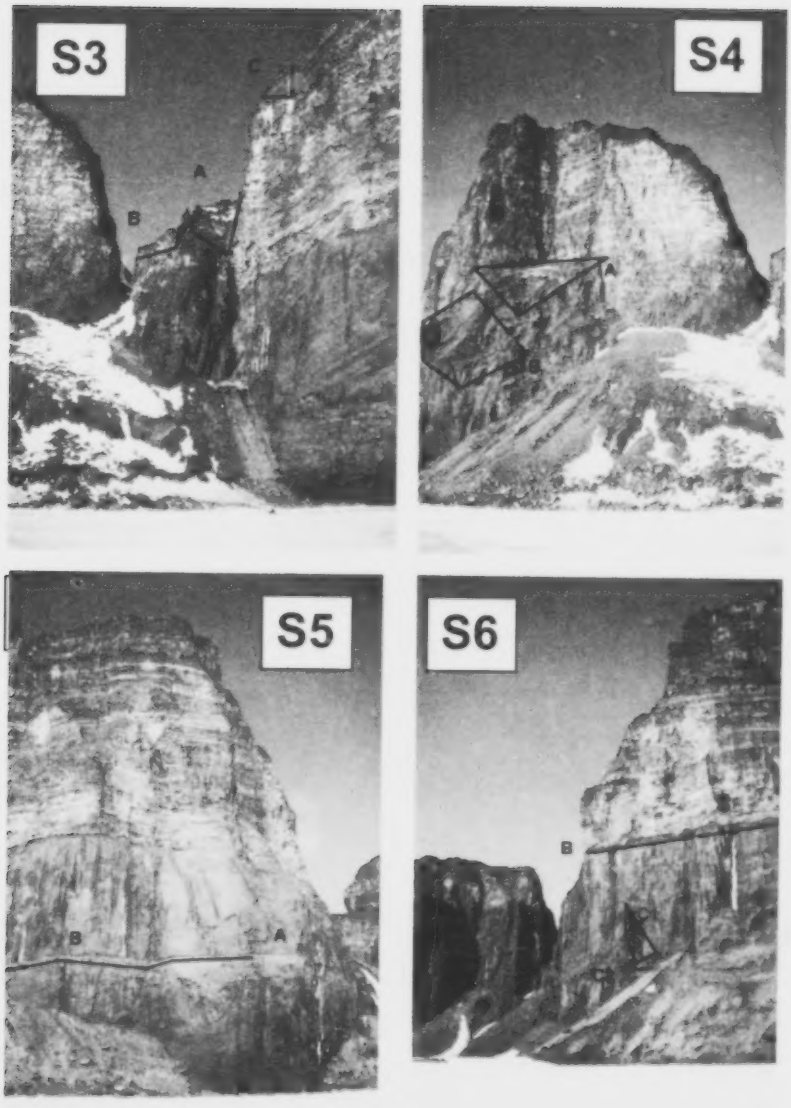
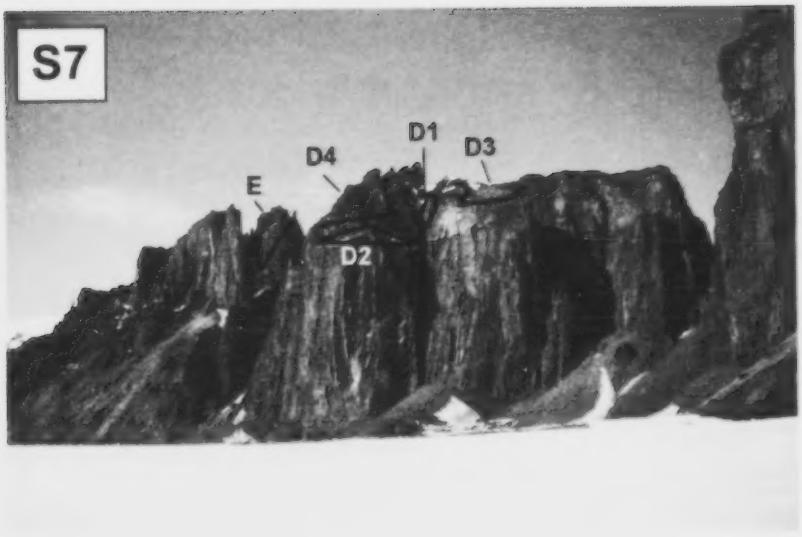
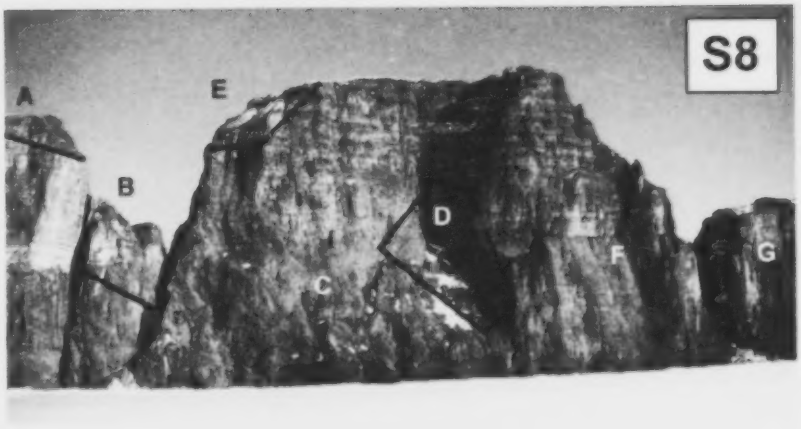
Appendix A. Census area photos from Cape Searle, referred to in Table 2.






S3
C
A
B
S4
A
S5
B
A
S6
B


S7
D1
D4
D3
E
D2


S8
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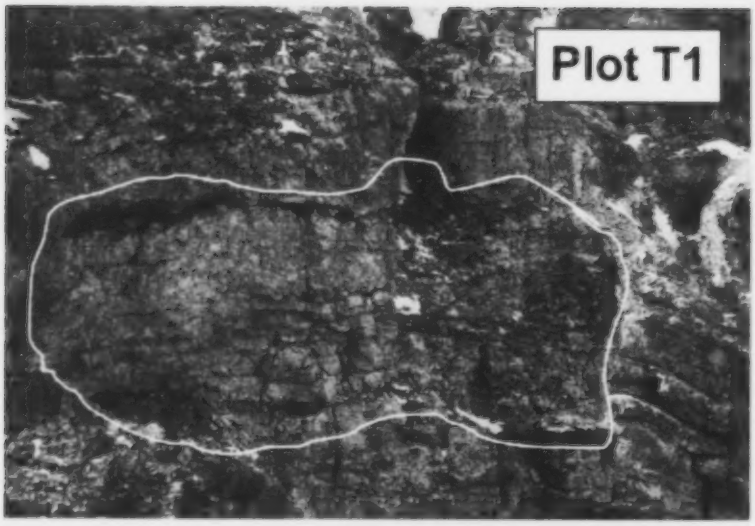
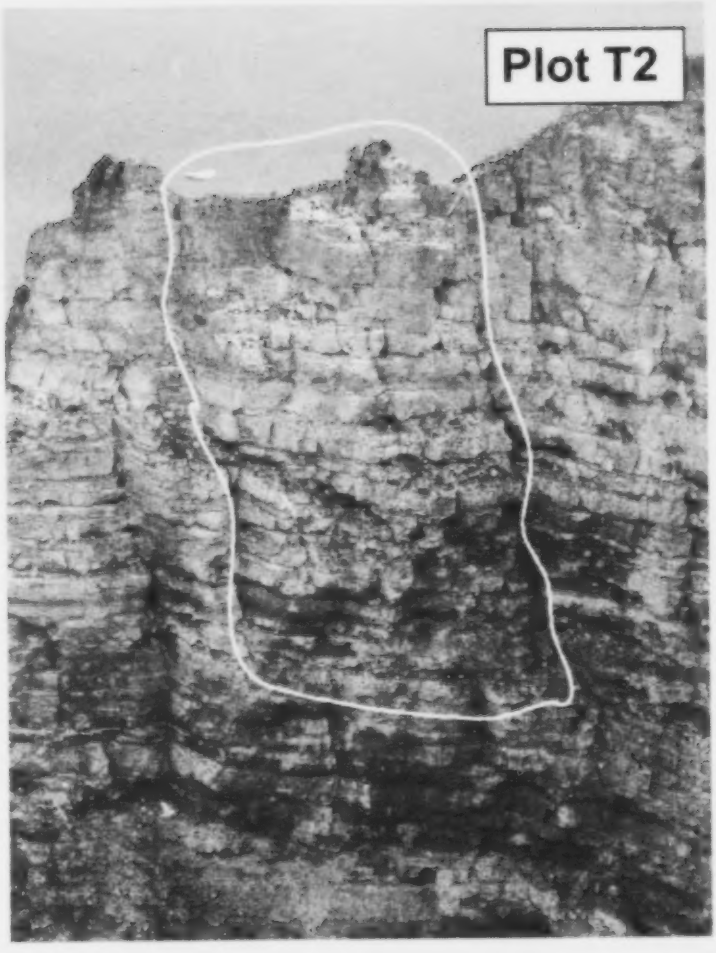
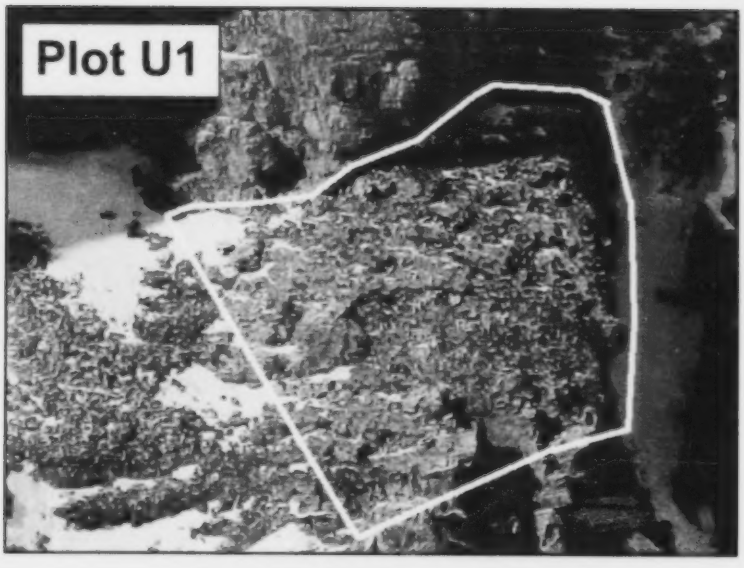
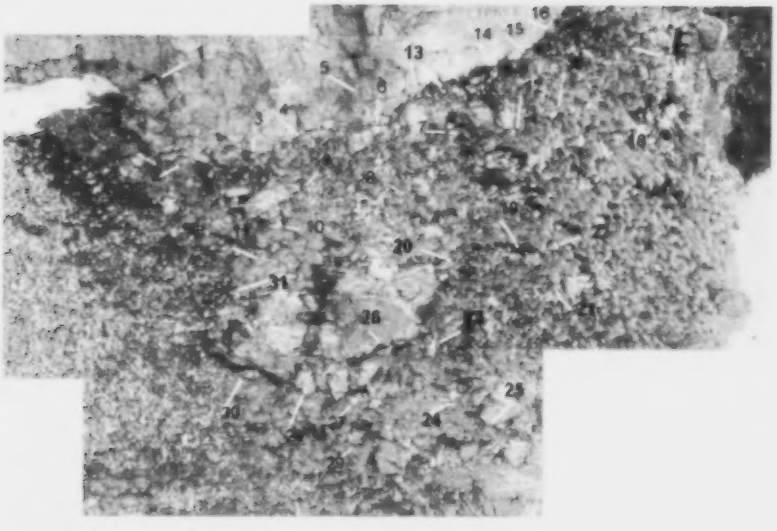
Appendix B. Monitoring plots at Cape Vera.




Plot T2


Plot U1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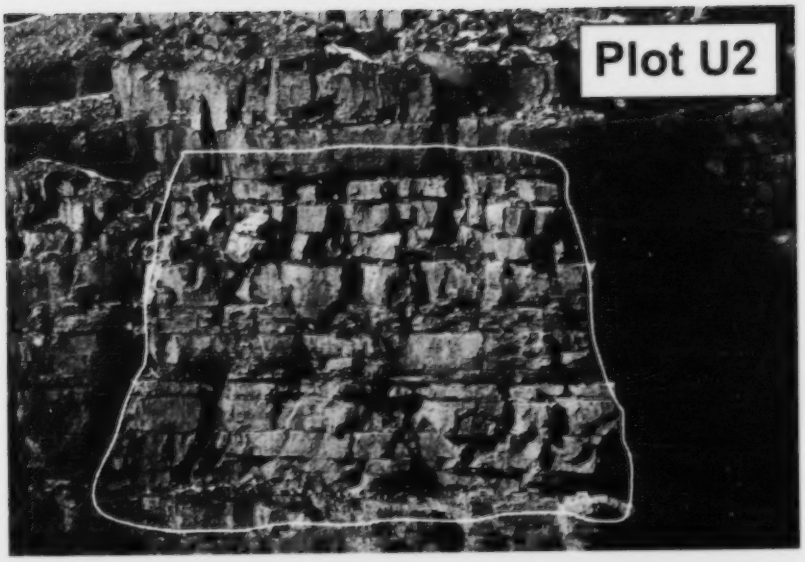
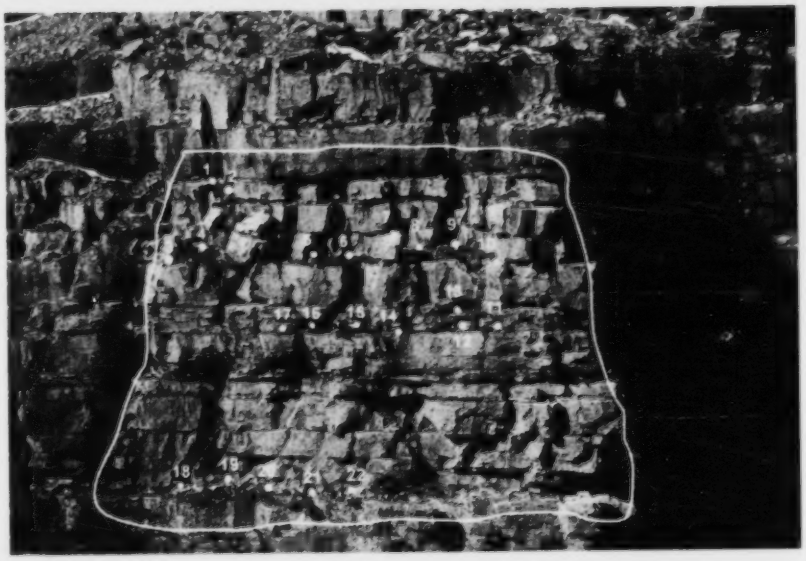
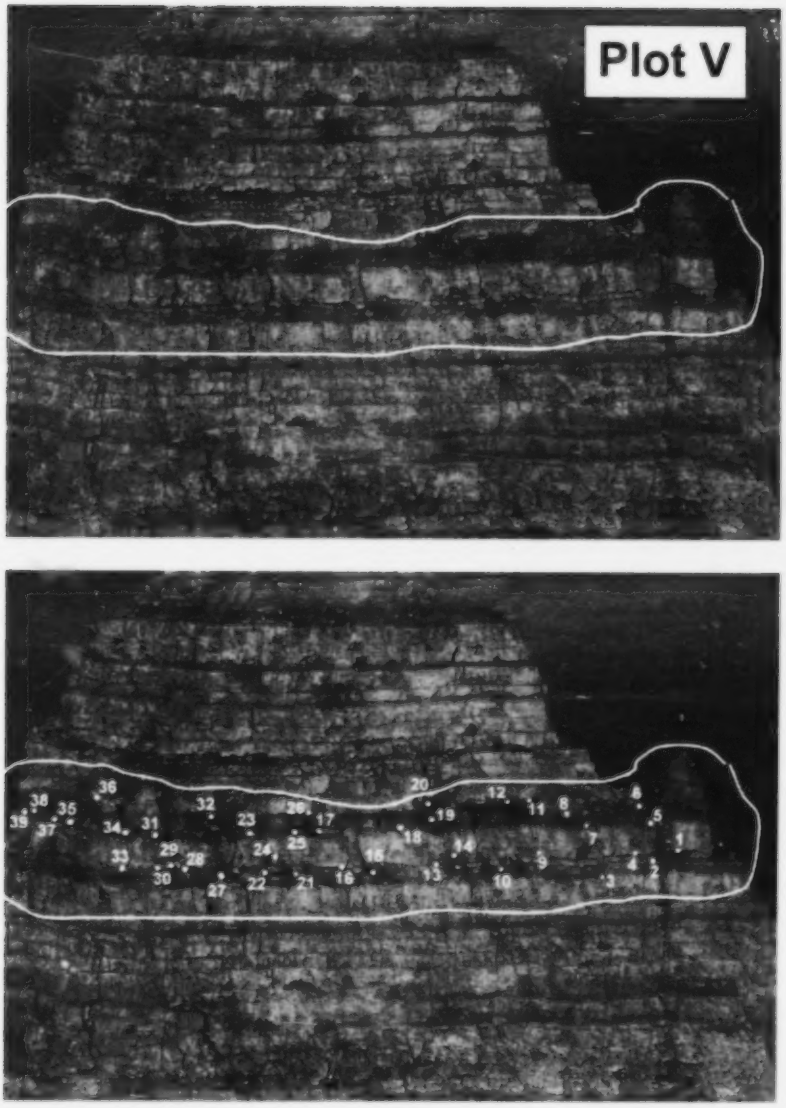

Plot U2




Plot V
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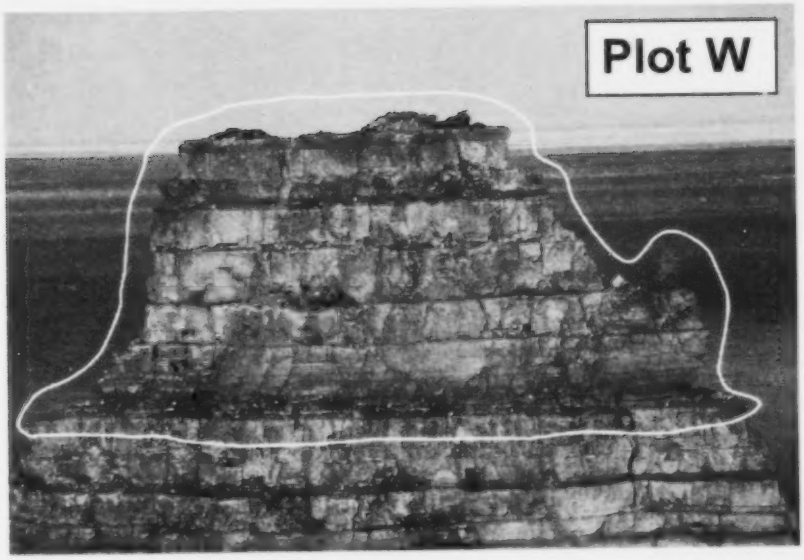
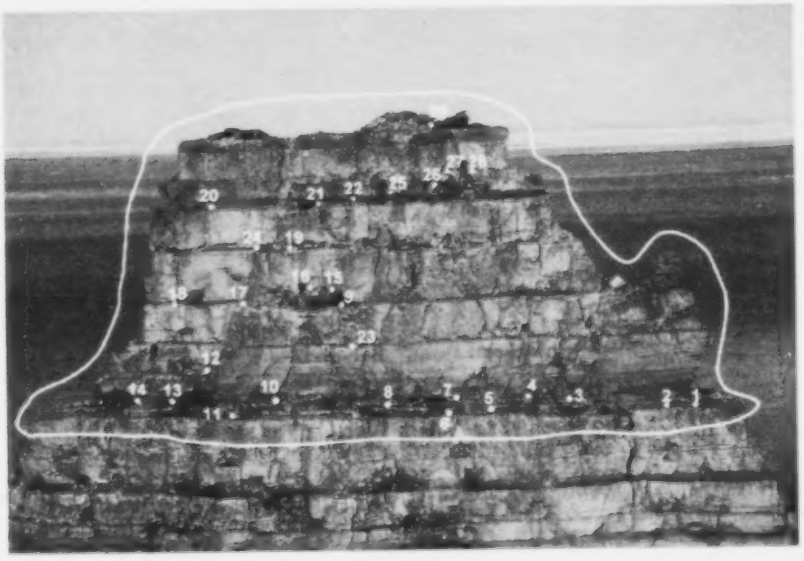

Plot W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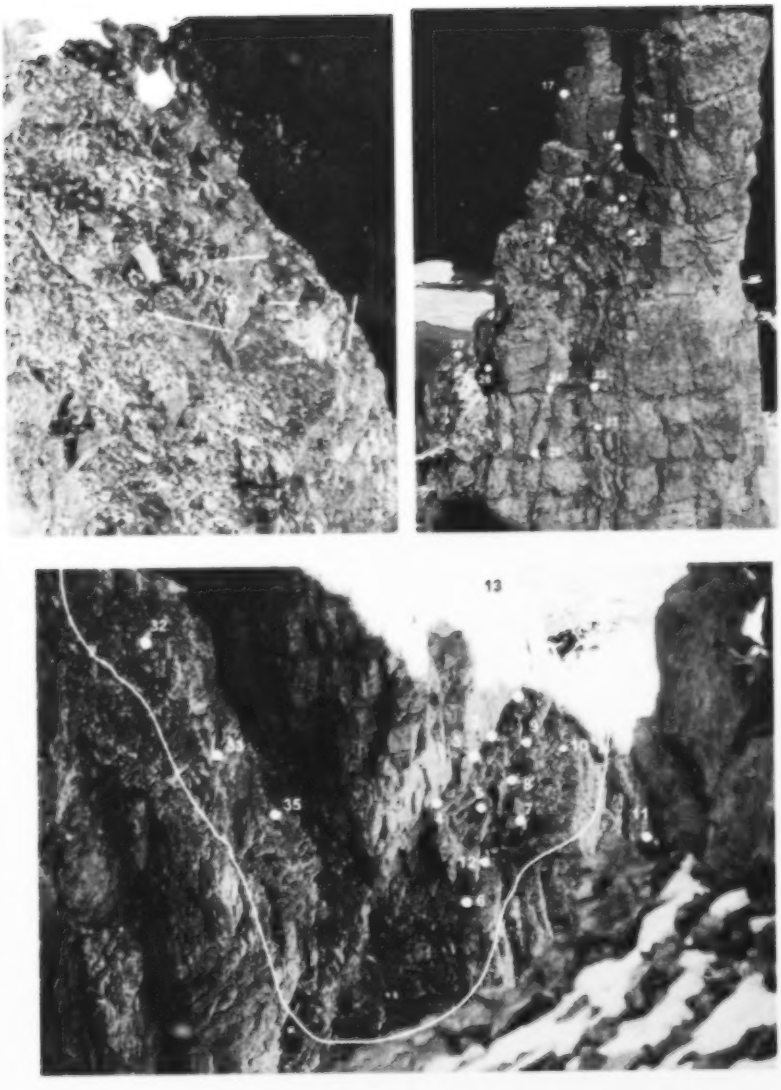
Plot X
X

X PLOT



Plot Y

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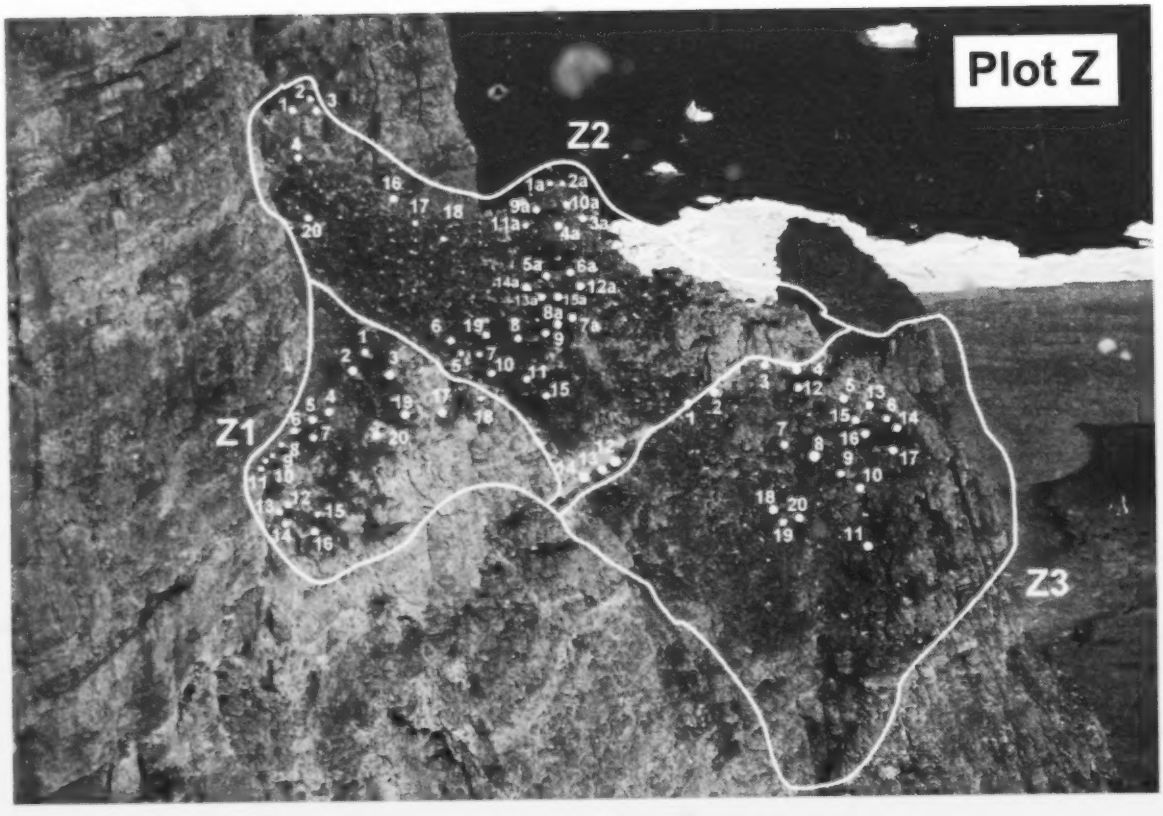
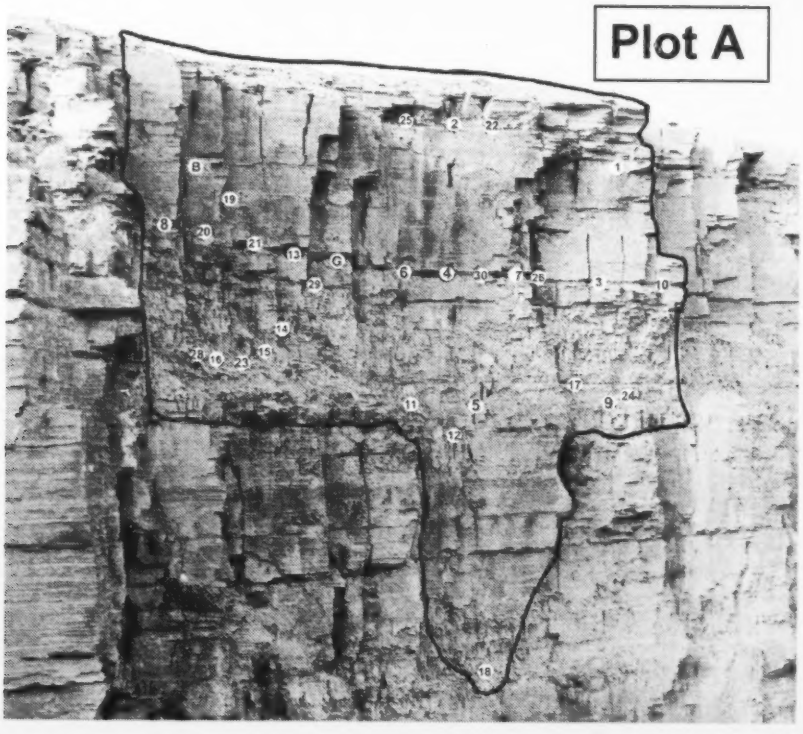
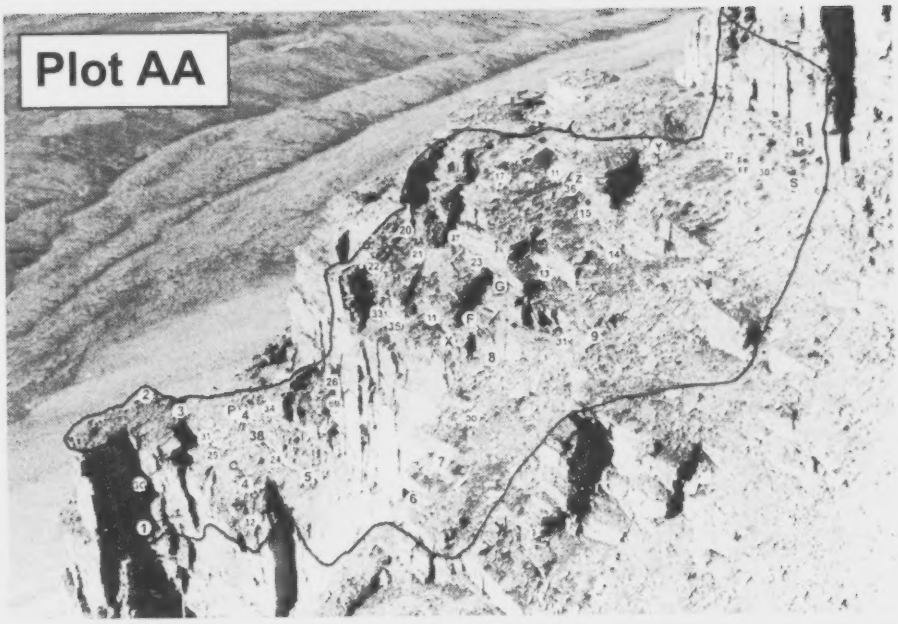
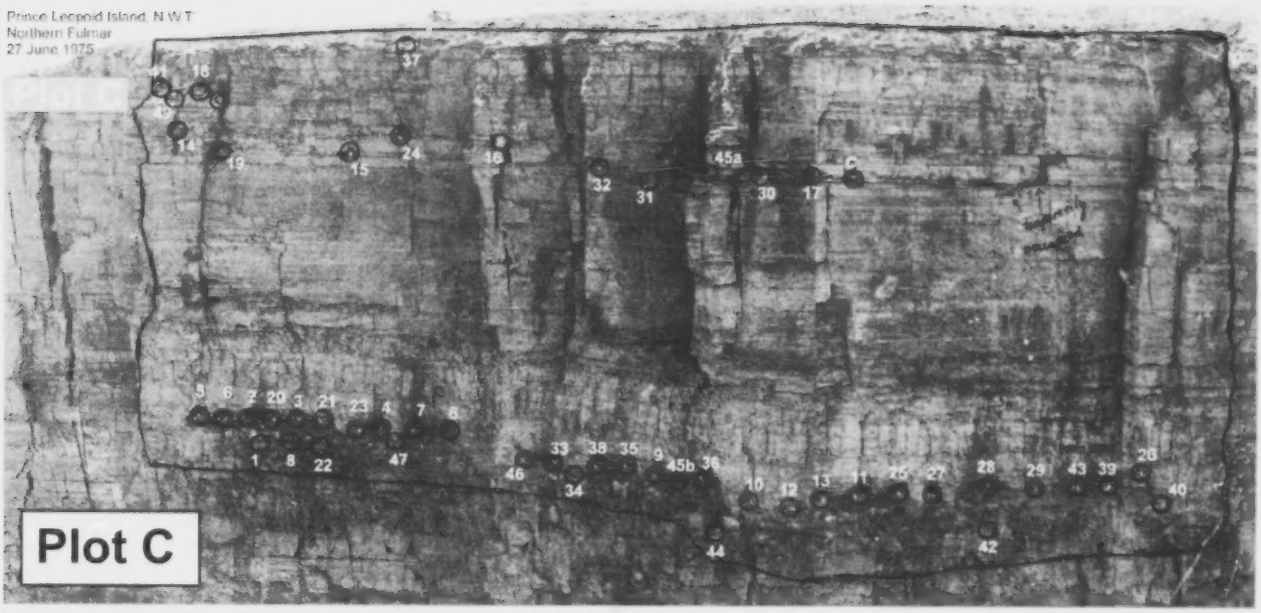
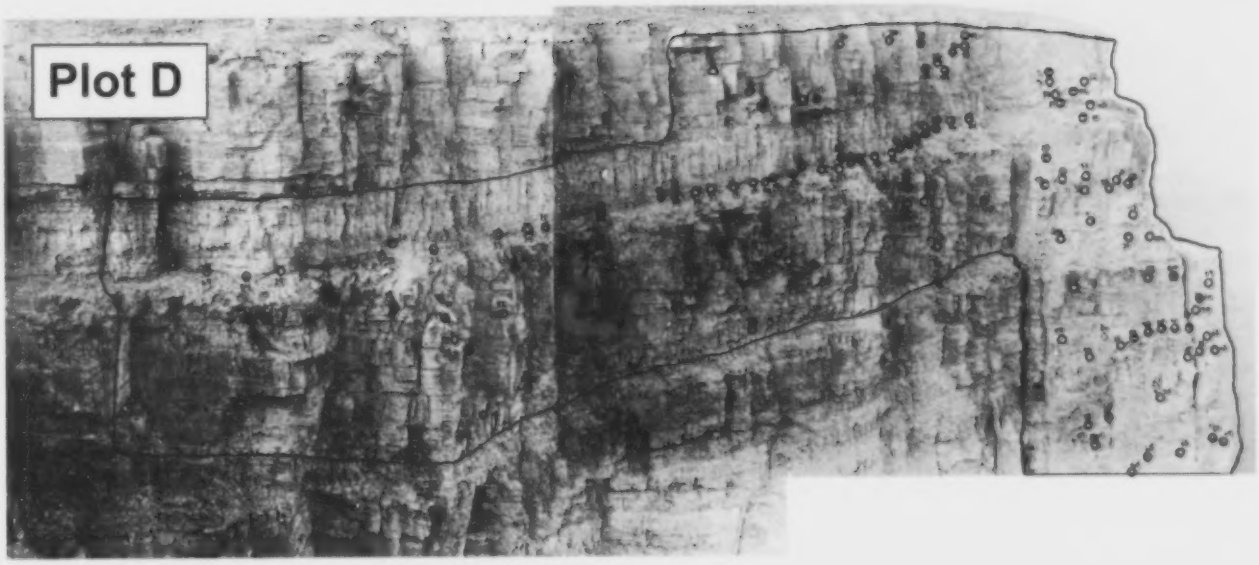

Plot Z
Z1
Z2
Z3

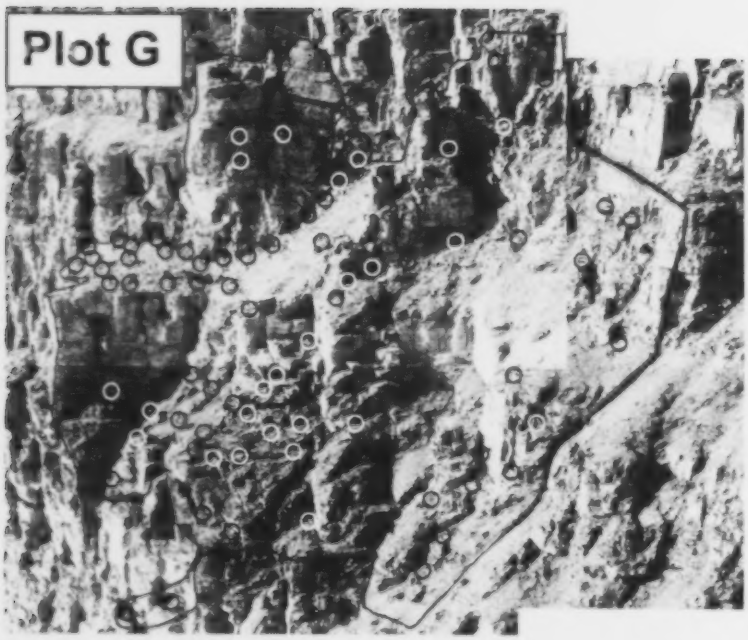
Appendix C. Plot photographs for Prince Leopold Island.

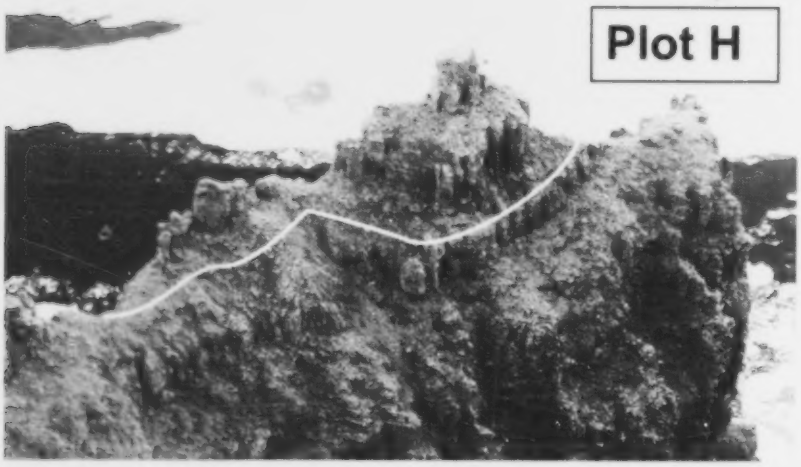



Plot AA

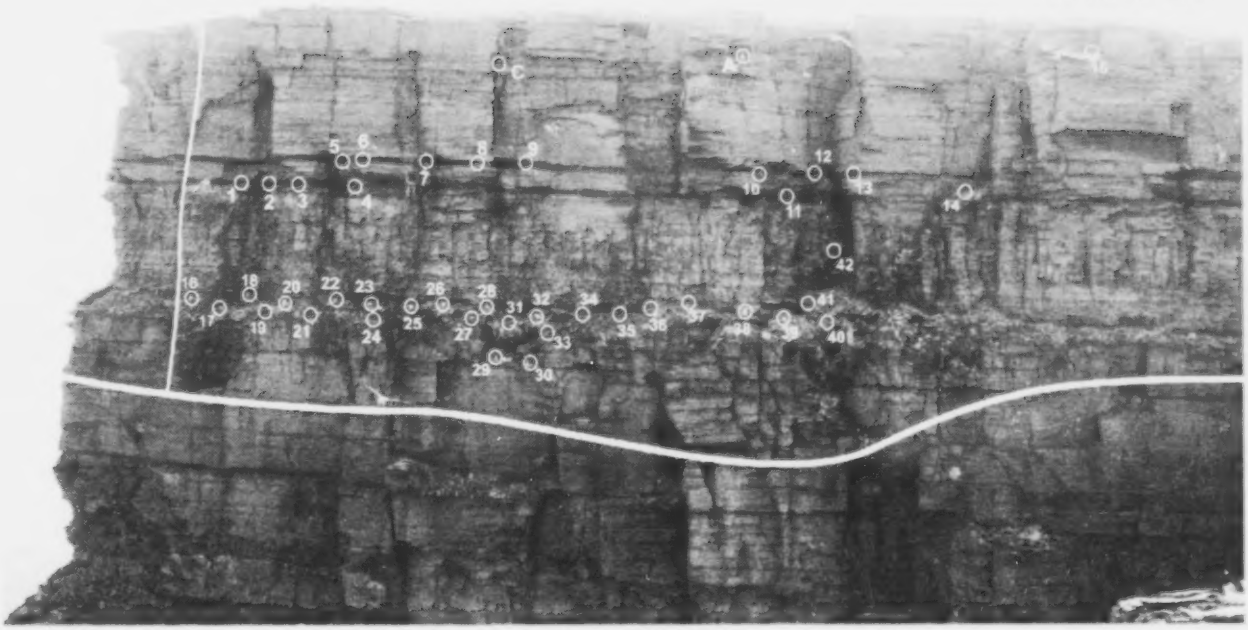

Prince Leopold Island, N.W.T.
Northern Fulmar
27 June 1975
Plot C


Plot D


Plot G


Plot H

Plot J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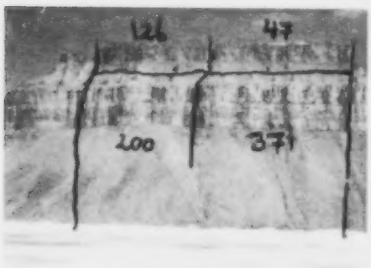
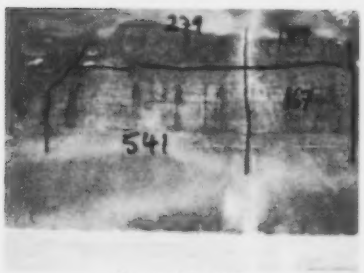
Appendix D. Count areas at the Hobhouse Inlet colony, 2 July 2001



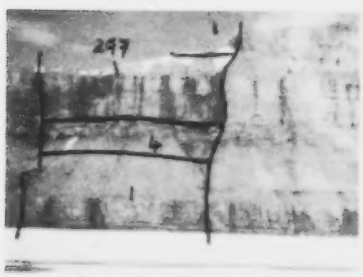
Counts from HI6

Counts from HI8 (east side)



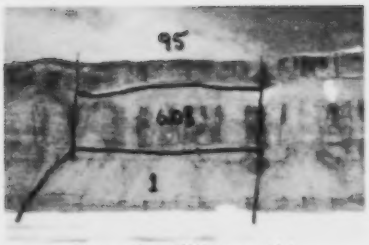
Counts from HI7

Counts from HI9 (west side)

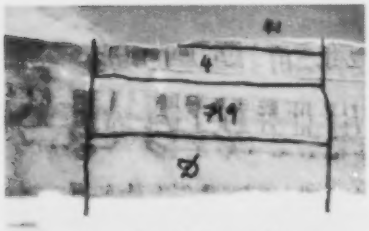


Counts from HI8 (west side)

Counts from HI9 (east side)

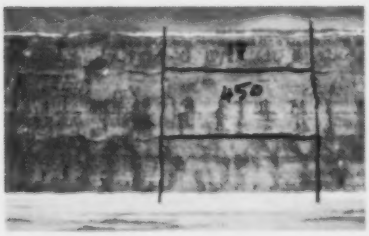


Counts from HI10 (west side)



Counts from HI10 (east side)

Counts from HI11 (west side)



Counts from HI11 (east side)

Over 50% recycled
paper including 10%
post-consumer fibre.